July 1990

The BEA Quarterly Econometric Model of the U.S. Economy: 1990 Version

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U.S. DEPARTMENT OF COMMERCE
Bureau of Economic Analysis

CONTENTS

PREFACE

This document describes the 1990 version of the Bureau of Economic Analysis (BEA) quarterly econometric model of the U.S. economy ("the model") and presents selected multiplier simulations to analyze response characteristics of the model.

A brief history of the model from its inception in 1962 to early 1990, when work was discontinued, follows. A bibliography of major studies related to the model, together with other references cited in this paper, is attached.

In 1962, the Office of Business Economics (OBE)--the precursor of BEA--initiated work to develop and use a quarterly econometric model of the United States economy. The work began with a 34 equation model, consisting of 29 stochastic equations and 5 identities, that Lawrence R. Klein had designed and turned over to OBE; essentially this model is described in Klein (1964). By 1965 OBE had redeveloped the model into its own distinct version and expanded its size to 49 equations (36 stochastic equations and 13 identities). That first version of the OBE model was published and described by Liebenberg, Hirsch, and Popkin (1966).

During the next two and one-half decades, the staff at BEA continued to develop and improve the model; later versions of the model were published in 1973 and 1986. Successive versions became larger and more complex in response to demand for more detail by Federal Government users, developments in model-building methodology, and major improvements in computer hardware and software capabilities that facilitated the building and application of larger models. By 1985 the model contained some 250 stochastic equations, including 60 stochastic near-identities. Overall, the model totaled between 600 and 1100 equations (depending on how one defines distinct identities).

In 1986, the operation and maintenance of the model was shifted to microcomputers from a mainframe computer. (The microcomputer-based model's equations were specified, estimated, and solved using the AREMOS software, distributed by the WEFA Group.) That transfer provided improved access to the model for users and improved productivity in model development research, model building, and model testing, including examination of model properties and evaluation of proposed changes in model structure. The transfer also provided easier access to the model by key users in other Government agencies. While the transfer required respecification of some equations and a moderate reduction in the size of the model, the model's essential features were preserved.

Regular forecasts using the model were initiated in 1967, and by 1990 were distributed to nearly 100 individuals in the Federal Government. The principal users of the model were the President's Council of Economic Advisers, the Commerce Department's Under Secretary for Economic Affairs, and the International Trade Administration. Various other individuals in more than 20 other Federal agencies received regular quarterly forecasts prepared using the model.

In addition, special analyses and simulations were prepared on an ad hoc basis, generally in response to official requests, to examine the impacts on the U.S. economy of various possible changes in fiscal policy or alternative scenarios involving external shocks, such as changes in world energy and food prices, a large movement in the average exchange rate for the U.S. dollar, or a prolonged strike in a major industry. The largest special analysis project was prepared in 1983 in response to a request from a National Commission on Social Security Reform. That study involved the preparation of alternative projections far into the future, and also entailed substantial expansion and modification of the model.

Over the years, the model has been modified, expanded, and improved by many economists at BEA. Model development at BEA benefitted from the writings, comments, and suggestions by other economists at BEA and other econometric modelers. Also, BEA's econometrics staff have participated in various conferences and projects designed to maintain communication with other model-development groups and to present research on model specification and properties. Of particular value in this regard was BEA's participation, along with other U.S. macroeconometric model builders, in the Model Comparison Seminar. This group has held periodic meetings in one form or another since the later 1960s to compare model structure and properties across models of the U.S. economy and to advance the art of model building.

The discontinuation of the model in early 1990 was one of several steps taken by BEA in order to reallocate needed resources to data improvement work on national and international economic accounts. For more information, see the *Survey of Current Business*, February 1990, p.2.

Economists who had major responsibilities for the structure of the 1990 version of the model are Christian Ehemann, George Green, Bruce Grimm, Albert Hirsch, Arnold Katz, Michael Mann, and Henry Townsend. Susan Sims managed the data and model maintenance efforts. Others who provided modeling and forecasting support include Stephen August, Elizabeth Brainerd, Rose Janifer, Francine McCullough, Lisa Mataloni, Patricia Pearson, Robert Sylvester, and Douglas Weinberg. Many others at BEA contributed greatly to the quality of the model and, more importantly, its forecasts. The 1990 version of the model builds upon and incorporates many aspects of former versions of the model. The efforts of all those who contributed to former versions of the model are gratefully acknowledged.

I. OVERVIEW

The 1990 version of the BEA model consists of 693 equations; 237 of these equations are "behavioral" or "stochastic" equations and the remainder (456) are identities. A substantial number (177) of the identities are not mathematically required to solve the model, but are side outputs that provide information that supplements the direct forecast results. The model thus falls in the category of "large" quarterly models, although it remains smaller than some commercial models that include substantial industry detail.

The model features "mainstream" product and income determination relationships, and embodies standard schemes of price and interest-rate determination. Like most models, it combines an eclectic mix of economic approaches and cannot be described as adhering faithfully to any one school of economic thought. Its distinctive features are: (1) use of a "top-down/bottom-up" approach for the determination of components of personal consumption expenditures and for GNP component price deflators--each set of components is then weighted to redefine the final estimate for the corresponding aggregate; (2) a mechanism for determining short-term interest rates that embodies presumed Federal Reserve System reactions to economic stimuli; and (3) exceptionally detailed outputs for Federal Government receipts and expenditures, including a translation from NIPA-basis receipts and expenditures to unified budget categories.

The model is designed for short-term forecasting and policy analysis. Goodness-of-fit of the equations, individually and as a system, and ease of use for forecasting were important criteria for equation selection. Nevertheless, theoretical reasonableness, especially with respect to long-run properties, was not generally sacrificed in favor of other considerations.

The model consists of ten broad sectors of equations: (1) personal consumption expenditures, (2) gross private domestic investment, (3) exports and imports of goods and services, (4) aggregate output identities and capacity utilization, (5) prices and wages, (6) employment and labor force, (7) income components and capital consumption allowances, (8) government receipts and expenditures, and (9) financial (i.e., money supply and interest rates).

Part II presents a concise description of each block of equations. Part III presents and analyzes full model multiplier paths for a variety of exogenous shocks.

II. DESCRIPTION OF EQUATIONS BY MODEL SECTOR

1. Personal Consumption Expenditures

The model uses a combined "top-down/bottom-up" approach to predict personal consumption expenditures (PCE). The top-down and bottom-up approaches to consumption each have strengths as well as empirical difficulties. The top-down approach begins with an aggregate consumption function and allocates predicted aggregate consumption to components. This approach does well in capturing the effects of general variables that affect all components of consumption (such as disposable personal income) but much less well in handling "component-specific" variables that affect only one component of consumption (for example, the rate of interest on auto loans). The bottom-up approach, which uses behavioral equations for consumption components and sums to get the total, is well suited to taking component-specific variables into account but often founders on multicollinearity problems when all of the general variables that affect consumption are included in the individual component equations.

The combined approach used in the BEA quarterly model involves estimation of both an aggregate consumption function and a complete set of component equations. The aggregate consumption function includes those general variables that help to explain all components of consumption. The component equations contain the predicted value of aggregate consumption (in most cases replacing the full set of general variables) plus relevant component-specific explanatory variables. The only role of predicted aggregate consumption from the aggregate consumption equation is to represent the general explanatory variables in the component equations; the model's prediction of total consumption is obtained by summing the components. This approach implicitly assumes that the relative importance of each of the general explanatory variables in the aggregate consumption function is the same for every consumption component. However, in cases where a different relative importance has been found, one or more of the general variables have also been included in the corresponding consumption-component equations.

1.1 The aggregate consumption function

The aggregate PCE equation is specified as a function of five variables: disposable personal income (adjusted), the ratio of net financial assets of households (excluding equities and mortgages) to adjusted income, the inflation rate, the difference between the civilian unemployment rate and its cyclically adjusted value, and the proportion of the population aged 16 to 74 years. The dependent variable and disposable personal income (DPI) are expressed in logarithms of their constant dollar per capita values.

Adjusted DPI is the most important explanatory variable. Its impact on PCE is distributed over 12 quarters. The adjusted measure of DPI is obtained by subtracting the value of interest paid by consumers and the portion of personal interest income that accrues to pension funds, and by smoothing farm proprietors' income. The inflation rate used is the rate of change in the consumer price index with a distributed lag. Both it and the unemployment variable have a negative effect on per-capita PCE. The share of the population in the 16-74 year age group has a positive effect on per-capita PCE, reflecting a lower-than-average spending propensity with respect to income by or for children and the elderly.

1.2 Components of PCE

The typical equation for a consumption component has the following form:

$$\ln (C_j) = b_0 + b_1 \ln (CEQ) + b_2 \ln (PC_j/PC) + \text{other terms}$$

where

C_j = constant-dollar expenditures for the J-th consumption component;
CEQ = constant-dollar PCE, as estimated by the aggregate consumption equation;
PC = the implicit price deflator for PCE;
PC_j = the implicit price deflator for the J-th consumption component.

The other terms consist of variables that either appear in the aggregate consumption equation or are uniquely relevant to the consumption component in question.

Motor vehicles and parts.–A single equation explains PCE for new and net used motor vehicles; an exogenous ratio splits off purchases of recreational vehicles and trucks, leaving purchases of new and net used automobiles as a residual. There are separate equations for auto parts and accessories.

In addition to CEQ, the motor vehicles PCE equation contains the unemployment rate, which significantly reinforces the cyclical volatility of auto purchases. The equation also contains the 4-quarter change in CEQ–an accelerator term that further emphasizes cyclicality, a relative price term that contains the interest cost on auto loans, the stock of autos held as dealer inventories, and the age composition of the consumer-held auto stock, as represented by the ratio of cars less than three years old to the total stock. Relatively large holdings of recent model stocks reduce purchases. The dealer-held stocks proxy for the effect of buyer incentive programs, which translate into lower effective costs that are not measured in the relative price term.

The auto parts and accessories PCE equation, which is in first-difference form, uses purchases of motor vehicles rather CEQ as the main explanatory variable. It also contains the lagged error term from the CEQ equation; a stochastic component of purchases of auto parts is positively correlated with this error term.

Other durable goods.--The furniture and equipment PCE equation contains the Federal Reserve Board's index of capacity utilization as a proxy for the procyclical nature of these purchases. It also contains the proportion of single persons in the total population with a negative coefficient. The equation for the remaining ("other") durable goods in PCE contains the (one-quarter) lagged stock of these goods and a positively signed trend.

Nondurable goods.--There are PCE equations for food, clothing and shoes, gasoline and oil, and other nondurables. PCE for home fuels is exogenous. The equations for PCE for food and for clothing and shoes each contain measures of changes in the own prices of the respective categories as well as levels of relative prices. These own-price changes have negative coefficients, implying that demand is more elastic in the short run than in the long run. The food PCE equation also contains a trend and the lagged CEQ error (again with a positive coefficient). The PCE for gasoline and oil equation includes a variable that measures the average miles per gallon achieved by the passenger auto fleet; the higher the mileage figure, the lower gasoline purchases. The estimated coefficient for this variable is well below one, suggesting that the consumer truck and recreational vehicle fleet has not enjoyed the same improvements in mileage achieved by the passenger auto fleet. The other nondurables PCE equation contains the relative proportion of singles to overall population, with a negative coefficient.

Services.--There are PCE equations for housing (including the imputed value of rent on owner-occupied housing), other household operation, transportation, and other services. PCE for electricity and gas is exogenous. The PCE for housing services equation (which is in first difference form) includes the housing stock (the average of beginning and end-of-period levels) with a virtually unitary estimated elasticity. The lagged housing stock appears with a negative coefficient. Population also appears with an estimated elasticity not significantly different from unity. The PCE for other household operation equation contains the relative proportion of singles in the total population with a positive coefficient and a positively signed time trend. The PCE for transportation equation (expressed in first-difference form) includes the unemployment rate with positive coefficient as well as CEQ, thus partly offsetting the negative impact of unemployment that is transmitted through the aggregate consumption term. It also includes a dummy variable representing the effects of airline deregulation. The equation for other (including medical) services includes a kinked time trend, one component of which is scaled by overall estimated PCE.

2. Gross Private Domestic Investment

2.1 Fixed nonresidential investment

Producers' durable equipment.--In the BEA equation for producers' durable equipment, the principal explanatory variable is a modified change-in-output (accelerator) term that incorporates an extraneously determined coefficient representing the replacement demand for equipment. Cost-of-capital components are represented in two variables. One variable is the relative purchase price of equipment, which uses the nominal wage rate in the denominator rather than the price of output, thus relating it to capital-labor substitutability. The other variable is the weighted sum of three cost-of-capital components: the nominal long-term interest rate, the expected rate of inflation in the price of equipment (as proxied by past inflation rates with a Pascal lag distribution), and a tax factor that measures the present value of the pre-tax income that a dollar's worth of investment must yield in order to make the investment profitable, i.e., to yield an after-tax income with a present value of one dollar. All explanatory variables are specified with distributed lags. All coefficients of the cost-of-capital variables have the same sign, which is consistent with a "putty-clay" technology, i.e., one in which factor proportions are fixed once the equipment is installed.

Underlying the model's equation for business investment in producers' durable equipment is the neoclassical theory of investment, as proposed by Jorgenson (1963) and modified by Bischoff (1971). Bischoff, in particular, assumed that the representative firm has a constant-elasticity-of-substitution production function. He showed that its optimum capital-output ratio (implying optimum factor proportions) equals the ratio of the price of its output to the implicit rental value of capital, raised to a power equal to the elasticity of substitution between capital and labor. Here, the implicit rental value, or cost, of capital is equal to the product of the purchase price of the capital good and the sum of the good's depreciation rate and the real rate of interest (the nominal interest rate less the expected rate of inflation in the price of the good), modified to account for the effects of taxation.

Bischoff's estimating equation for equipment investment has two explanatory variables, each entering with distributed lags: (1) the product of the static optimal amount of equipment per unit of capacity, V, in a given quarter and the level of output in the subsequent quarter; and (2) the product of V and the level of output in the concurrent quarter. Depending on the estimated parameters, this equation can imply either a "putty-clay" or a "putty-putty" technology. If the technology is putty-clay (i.e., one in which the factor proportions are fixed once the equipment is installed), then investment reacts to the level of V but not to changes in it. In that case, both recent and remote relative prices enter with the same sign. If the technology is putty-putty (i.e., one in which factor proportions are variable both before and after equipment is installed), remote relative prices may enter the equation with a sign opposite those for recent prices because investment is a function of changes in V. Whether the technology is putty-clay or putty-putty, the acceleration principle holds, i.e., investment is a function of the change in the level of output and not the level itself.

The BEA model's equation for equipment investment differs from Bischoff's in that it has separate variables for the various cost-of-capital components. Just as Bischoff's equation can be viewed as a generalization of Jorgenson's because it permits output and V to have different lag structures in contrast to the single one imposed by Jorgenson, the BEA equation can be viewed as a generalization of Bischoff's. The use of separate variables for the various (user) cost-of-capital components can be justified on theoretical grounds. The user-cost expression used by Jorgenson and Bischoff is based on various simplifying assumptions, some of them unrealistic. For example, their formulation assumes that it is the real and not the nominal interest rate that matters for investment decisions, which implies that businessmen are indifferent between a 1-percent increase in the nominal interest rate and a 1-percent decrease in the rate of inflation of capital goods prices. Because of risk and uncertainty, such an assumption seems unwarranted. Accordingly, the BEA model's equation for equipment investment relaxes this assumption by permitting the data to set different coefficients on the interest rate and inflation components.

Nonresidential structures.--Gross private domestic investment in nonresidential structures is determined by a pure accelerator model. The only explanatory variable is real private domestic nonhousing product less 87 percent of its value in the previous quarter. This variable, which enters with a distributed lag, combines an accelerator component and a replacement component, for which the associated investment is proportional to output. The replacement effect is built in with an a-priori parameter, rather than empirically estimated, because the resulting positive coefficient on the stock variable would be destabilizing, that is, an overestimate (underestimate) of investment would cause the gross stock to be overestimated (underestimated), which in turn would cause future estimates of investment to be overestimated (underestimated). The estimated parameters of the equation imply that if real GNP growth is close to its average long-run rate, the ratio of investment in structures to GNP will exhibit a small secular decline. The principal theoretical weakness of this equation is that no cost-of-capital terms are included. However, attempts to include either single cost-of-capital expressions or disaggregated components of the cost of capital were not empirically successful.

2.2 Residential investment

Residential investment is disaggregated into six components--investment in new single-unit structures, new multi-unit structures, additions and alterations, purchases of residential producers' durable equipment, mobile homes (exogenous), and a residual component (mainly brokers' commissions).

Investment in new structures.--Investment in new single-family and in new multi-family unit residential structures are each estimated in a two-step sequence. One pair of equations estimates the constant-dollar value of starts in single-family and multi-family structures, respectively. A second pair uses phasing relationships to translate each value of starts into construction put in place.

The constant-dollar value of single-family housing starts is made a function of a relative price term, an income term, two credit terms, and the lagged dependent variable. The price term measures the implicit rental price of housing relative to the price of other consumer goods. It is equal to the product of the user cost of capital for housing, which is defined as the real after-tax unit cost of interest and property taxes, and the ratio of the purchase price of housing to the PCE implicit price deflator. Here, before-tax nominal unit cost is equal to the mortgage interest rate plus the property tax rate. The latter is estimated as total residential property taxes divided by an approximation to the taxable value of the housing stock.

The constant-dollar value of multi-family starts is made a function of the ratio of the consumer price index for rent to the GNP deflator, a moving average of the housing vacancy rate, credit conditions as measured by a function of the spread between the mortgage interest rate and the 4-6 month commercial paper rate, and the availability of funds as measured by the relative change in deflated small time and savings deposits. The equation also uses a lagged dependent variable.

The income tax deductibility of mortgage interest and property taxes is accounted for by multiplying pre-tax costs by one minus the effective average Federal-plus-State/local personal income tax rate. The expected rate of inflation in housing prices, which is used to construct a real interest rate, is measured using a geometrically declining weighted average of lagged inflation rates in the residential investment deflator. The affordability of housing is measured by the ratio of real disposable personal income to the residential investment deflator. Credit conditions are proxied by the short-term commercial paper rate and a dummy variable for periods of extreme credit rationing.

The number of housing units started of each type of structure--which are side outputs of the model--is determined by dividing the constant-dollar value of each type of start by the corresponding average constant-dollar value per start. For single-family structures, the average constant-dollar value per start is made a function of its lagged value, the relative change in the constant-dollar value of these starts, and the ratio of the constant-dollar value of single-family starts to that of all starts. The average constant-dollar value of a multi-family housing start is exogenous.

Other residential investment.--Constant-dollar investment in additions and alterations, which is now a sizable proportion of total residential investment, is determined by making the ratio of this investment to the housing stock a function of its relative price (the ratio of its deflator to the deflator for PCE), short-term credit conditions as measured by the commercial paper rate, and a lagged dependent variable. Investment in residential producers' durable equipment is made a function of new investment in single-family and multi-family structures and replacement investment, which is assumed to be a fixed proportion of the lagged value of the constant-dollar housing stock.

Other residential investment, including brokers' commissions, is made a function of investment in single-family structures and resales, which are assumed to be proportional to the constant-dollar housing stock.

2.3 Inventory investment

The change in business inventories (i.e., inventory investment) is disaggregated into three components: farm, auto, and nonfarm nonauto inventories. Farm inventory investment is exogenous.

Nonfarm nonauto inventories.--Investment in nonfarm nonauto inventories, estimated as the relative change in the stock of these inventories, is made a function of five variables: the ratio of final sales of nonfarm nonauto goods to the lagged stock of inventories, the difference between actual and expected final sales divided by the lagged inventory stock, the expected rate of inflation as measured by a weighted average of recent actual rates of inflation, and a pair of cyclical variables that represent deviations of the growth rates of the stock of inventories and output from their respective past maximum values. The latter two variables permit inventory accumulation to behave asymmetrically in expansions and recessions. (Efforts to include the nominal rate of interest with a positive sign to capture the cost of holding inventories were not successful.)

The concept of sales used in this equation is gross domestic private final sales plus merchandise imports less consumer auto purchases, consumption and exports of services, and Commodity Credit Corporation purchases. Expected sales are determined by an equation that was obtained by regressing the current change in final sales on previous changes in these sales and a cyclical variable. The difference between actual and expected sales, i.e., the amount of sales "surprise," causes inventories to be run down (run up) if the level of final sales in unexpectedly high (low).

Auto inventories.--Auto inventory investment is made a function of purchases of autos by consumers and businesses, the change in these purchases, a real interest rate, and the lagged stock of auto inventories. The real interest rate is proxied by the nominal effective rate on commercial paper less the 4-quarter rate of change in the price of autos purchased by consumers and businesses (the expected inflation proxy).

Total real inventory investment is reflated into current-dollar investment using the aggregate Producer Price Index. Because that index is generally not equal to the implicit price deflator for inventory investment, a stochastic "pseudo-identity" links current and constant-dollar inventory investment.

3. Exports and Imports of Goods and Services

The model contains equations for aggregate merchandise exports and imports net of certain exogenous components. Exports and imports of services are each disaggregated into factor income payments and other services.

3.1 Merchandise exports and imports

Standard demand specifications underlie the merchandise trade equations. In abstract terms, aggregate demand for foreign goods (i.e., by U.S. residents from the rest of the world and vice versa) is primarily a function of income or activity in the importing area and relative prices (domestic to foreign or vice versa), including the effects of changes in the exchange rate. Both the exports and imports equations are estimated in current dollars and in log-linear form. Substantial problems in the measurement of trade prices warrant the use of current-dollar measures to avoid serious errors-in-variables bias. Consistent with the overall framework of the model, the trade measures are on a national income and product account basis rather than on a balance of payments account basis.

The dependent variables of the trade equations exclude certain goods that are largely determined by special factors and are accordingly made exogenous. In particular, the merchandise exports equation excludes agricultural products, aircraft, and automobiles and automobile parts exported to Canada. The merchandise imports equation excludes petroleum imports and automotive imports from Canada. Automotive imports from other countries are determined by a simple relationship to current and lagged domestic sales of foreign automobiles.

Foreign activity is represented by a trade-weighted index of foreign industrial production, a proxy for income earned abroad. U.S. activity is represented by private domestic nonfarm GNP, excluding housing output. The imports equation also uses U.S. capacity utilization to reflect cyclical sensitivity. Relative prices are represented by a trade-weighted measure of foreign wholesale prices for manufactures, U.S. merchandise export prices, and a trade-weighted measure of the value of the U.S. dollar. With the exception of export prices, these explanatory variables are exogenous. The relative price terms enter the equations with distributed lags.

3.2 Exports and Imports of Services

Exports and imports of services are each comprised of a number of different types of transactions. The principal types fall into two categories: factor income and other services. Factor income includes interest income, corporate profits, and wages. Other services include travel and passenger fares, other transportation, military transactions, royalties and license fees, and other private services. Net rest-of-the-world income (i.e., factor payments received from the rest of the world less factor payments to the rest of the world by the United States) consists of the net payments of interest, corporate profits, and wages. Separate sets of gross flow equations determine net interest and profits, net wage payments are exogenous.

Net interest.--Net rest-of-the-world interest is derived as interest received from foreigners less interest paid to foreigners. Interest received from foreigners, expressed as a ratio to lagged foreign financial liabilities, is made a function of a weighted average of short- and long-term interest rates with a distributed lag and a nonlinear time trend. U.S. short- and long-term rates are used as crude proxies for foreign rates; the weighted average approximates the proportion of short- and long-term financial instruments in domestic and foreign-held portfolios. The trend term shows increasing returns over time, but probably also reflects a trend in the asset mix and/or a trending wedge between U.S. and foreign interest rates.

Interest paid to foreigners is modeled with interest plus corporate profits paid to the rest of the world divided by lagged foreign assets held in the U.S. as the dependent variable. The explanatory variables are: (1) the ratio of the domestic price level to the productivity-adjusted wage rate and (2) a trend term indicating that the return increases over time (as it should because of distortion in the available measures of direct investment based on historical costs).

Gross foreign financial assets held in the United States is made a function of the change in net foreign assets, the change in U.S. gross domestic product, the 3-month U.S. Treasury bill rate, and the trade-weighted value of the dollar, which enters with a negative coefficient as a rising dollar increases the risk of investment in the United States. Net foreign financial assets held in the United States is set equal to last quarter's value less net foreign investment, which is essentially determined by net exports. Gross foreign financial liabilities is then derived residually as the difference between gross and net foreign financial assets.

Net rest-of-the-world corporate profits.--Corporate profits paid to the rest of the world, expressed as a ratio to domestic profits less profits of the Federal Reserve system, is made a function of the ratio of foreign financial assets to domestic product and the lagged dependent variable. Corporate profits received from the rest-of-the-world is exogenous. Net corporate profits received is determined residually, as is net interest.

Other services exports and imports.--The other trade services equations are estimated in real dollars. Both use merchandise trade flows (to which such services are strongly related) and relative price terms as explanatory variables. Each equation also contains a lagged dependable variable and a time trend, beginning in 1986, to account for the discontinuity that results from a large upward revision in the NIPA categories of business and professional services, travel and passenger fares, and students' expenditures. (The NIPA's have yet to be revised prior to 1986.) The imports equation also contains a capacity utilization term as a cyclical measure.

4. Aggregate Output, Key Sector Outputs, and Capacity Utilization

Gross national product, in current and constant dollars, is obtained from the product side as the sum of personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government purchases of goods and services. Model equations underlying the first three components have been discussed. The stochastic equations for endogenous (State and local government) purchases and the identities that yield total government purchases are described in Section 8.

Private domestic nonfarm GNP excluding housing (X) is a basic output variable that is used as a major behavioral determinant in such key equations as those for nonresidential fixed investment, imports, employment, average weekly hours, and capacity utilization. It is obtained by subtracting from GNP rest-of-the-world GNP, GNP originating in government (compensation of employees), gross farm product, and housing output. The second and third of these components are essentially exogenous. Rest-of-the-world GNP is discussed in Section 3. Housing output is derived from PCE for housing services (see Section 1) by subtracting out housing intermediate products (exogenous).

A Cobb-Douglas production function is used to derive a measure of X at peak production levels (XP) based on fully utilized labor and capital. The economy-wide "utilization" ratio, X/XP, is then used as an explanatory variable in the equation for the Federal Reserve Board's index of capacity utilization for manufacturing (and for its primary and advanced processing component indexes). The latter, in turn, are used as cyclical or demand pressure variables in price and certain other model equations.

5. Prices and Wages

In 1989, a "top-down/bottom-up" approach for price determination was reintroduced into the model to replace a stage-of-processing approach used during most of the 1980s. Under the latter approach, GNP goods component implicit price deflators were determined in part by materials input prices, labor cost, energy costs, and farm and import prices. In recognition of their importance, energy costs, farm and foreign prices, and the exchange rate continue to have an explicit role in the current scheme.

The current price-wage sector is structured as follows. An aggregate fixed-weighted price measure, representing the domestic price level, and a representative imported goods price measure are used as drivers in equations for GNP component price deflators. Each final demand component deflator is largely explained by the domestic and imported price indexes weighted in accordance with the relative proportions of domestic and imported commodities in that component. Prices of services (except for international factor payments and receipts, and, to a large extent, construction prices) are virtually unaffected by foreign prices and are accordingly made functions only of the domestic aggregate price index.

The basic structural equations in the price-wage sector are: (1) the equation for the domestic price index (PDOM), (2) the equation for the representative imports price, the implicit deflator for nonoil merchandise imports (PIMMERX), and (3) the equation for the nonfarm private sector wage rate (WRX). PDOM is the fixed-weighted price index for gross private domestic product plus imported petroleum, less PCE for food, energy and housing and business purchases of office, computer, and accounting equipment. Determination of which components were to be driven by this index was based primarily on goodness-of-fit criteria.

5.1 Aggregate price and wage rate equations

Aggregate domestic price index.--The equation for PDOM represents essentially a variable markup over standard (or normal) unit labor cost, for which the labor-productivity (i.e., output-per-hour) component is a simple average of trend and previous peak productivity. It includes a demand pressure term that combines, in distributed-lag form, a nonlinear capacity utilization variable with the deviation of the rate of change in nonfarm business final sales from its long-run average. It also embodies pass throughs of energy price changes as well as transitory profit absorption of changes in intermediate goods imports prices. The merchandise imports deflator is made a function of the exchange rate (i.e., the value of the dollar), foreign manufactured goods prices, and world commodity prices.

Wage rate.--An aggregate nominal wage rate, compensation per hour in the nonfarm private sector, expressed in relative first-difference form, is made a (nonlinear) function of the unemployment rate for married men, which is a very sensitive indicator of overall labor market tightness. Other explanatory variables are the (distributed) lagged changes in the wage rate, reflecting different lags in the transmission of labor market pressures to different sectors of the economy, and a weighted combination of domestic and foreign product prices. General product prices are used instead of consumer prices because international competition limits the ability of American firms and workers to pass forward cost-of-living increases as price changes for many commodities are increasingly determined in world markets.

The competitive effect of imported-goods prices is made operational through the inclusion of PIMMERX together with PDOM in a single variable that has varying weights determined by the share of nonoil imports in real nonfarm business GNP plus these imports. The final explanatory variable is an overall contribution rate to social insurance funds that incorporates the assumption that one-half of the initial effect of a change in the rate is eliminated (i.e., "passed backwards") over a three-year period.

5.2 Implicit price deflators for GNP components

As noted, GNP component price deflators are largely explained by weighted combinations of the domestic price index (PDOM) and the nonoil merchandise imports deflator (PIMMERX). Additional trends or "step functions" are sometimes used to handle empirically shifting relationships, as in the cases of the deflators for consumer purchases of clothing and shoes and "other" nondurable goods. In some equations (such as those for residential and nonresidential structures deflators and the deflators for household operation, transportation, medical and other consumer services) only the domestic driver is used. The deflator for household operation services except gas and electricity is made a direct function of unit labor cost. The deflator for State and local government employee compensation is made a simple function of the nonfarm private sector wage rate.

Certain deflators, such as those for consumer food and energy prices and agricultural exports, are made functions of particular appropriate commodity prices. The deflators for nonagricultural merchandise exports and for imports of services other than factor income depend partly upon the exchange rate. The deflator for business purchases of producers' durable equipment purchases is made a function of iron and steel product prices (retained from the former stage-of-processing approach, because apparently only its inclusion makes this equation workable) as well as the weighted domestic/foreign driver price. An equation for the rest-of-the-world product deflator is constructed to reflect the latter's equivalence to the deflator for net national product. It is made a function of the GNP deflator and a price index for depreciation.

5.3 Other price indexes

The model also generates, as by-products, two variants of the Consumer Price Index (CPI); the overall Producer Price Index (PPI), determined by the (endogenous) PPI for manufactures and the (exogenous) farm products price index; and fixed weighted price indexes for GNP, final sales, and final sales to domestic purchasers. Both the "All urban households" and "Urban wage earners and clerical workers" variants of the CPI are derived; the latter feeds back into government transfer payments, such as social security benefits. Predictions of the fixed-weights indexes are derived by applying 1982 weights to implicit deflators for the most disaggregated product components in the model.

6. Labor Demand and Supply

6.1 Employment and average weekly hours

There are two basic data series for employment: establishment-basis employment, which measures the number of jobs, and household-basis employment, which measures the number of persons holding jobs. The former is more closely associated with the working of the economy--specifically, with the level of output--while the latter is associated with the size of the available labor force. Because the model requires both types of linkages, both measures occur. Output, productivity, and the wage rate determine establishment-basis employment. A bridge equation links household-basis to establishment-basis employment.

Establishment-basis employment.--The key employment equation explains the rate of growth in establishment-basis employment in the nonfarm private sector in terms of both long-run and short-run factors. The dominant short-run determinant is the rate of change of nonfarm private sector output (estimated over an eight-quarter lag). This factor is partially offset by the trend rate of growth in labor productivity (output per hour), with an estimated coefficient of minus one; the labor productivity trend is measured by connecting and projecting through peak levels of actual productivity, expressed in log-linear form.

The equation also includes a measure of labor market disequilibrium--the real wage rate less the marginal product of labor (derived from a Cobb-Douglas production function) with the expected negative sign. The equation's ability to track the timing of employment changes during recessions and recoveries is enhanced by a variable that measures the difference between the relative decline in output from its peak less the relative decline in employment (lagged one quarter) from its peak. The ratio of trend to realized labor productivity (lagged one quarter) is the main long-run determinant. The negative coefficient on this ratio tends to move employment in the direction that will bring realized productivity closer to its trend.

Average weekly hours.--The equation for average weekly hours (establishment basis) explains the change in average weekly hours in the nonfarm private sector in terms of four variables. Two appear also in the employment equation: the rate of growth in nonfarm private output (again with an eight-quarter distributed lag) and the wage-rate based measure of labor market disequilibrium. The other two variables are the labor force participation rate and (for the period prior to 1979) a time trend; both of the latter variables have negative coefficients. The labor force participation variable reflects the fact that as more family members seek jobs, more of the jobs held are part-time.

Employment and hours worked for government employees, for proprietors, and for farm workers are exogenous.

Household-basis employment.--The bridge equation relating establishment-basis and household-basis nonfarm wage and salary employment uses the difference between these measures as its dependent variable. The main explanatory variable is a two-period average of the number of unemployed married men. When the number of unemployed married men rises, the number of job losers will normally be greater among workers covered by the establishment survey than among those covered by the household survey, in which workers at greatest risk of losing their jobs are under-represented. Hence, the excess of establishment-basis over household-basis workers narrows. The equation also contains a lagged dependent variable. Household employment other than wage and salary workers is related to the farm/nonfarm composition of this employment on an establishment basis.

6.2 Labor force and unemployment

Civilian labor force.--The civilian labor force is determined by behavioral equations for the labor force participation rates of three demographic groups: married men (spouse present), married women (spouse present), and others ("singles"). The populations of these three groups--the denominators of the participation rates--are exogenous. Because labor force participation of persons over age 74 is low, the populations used in the model are for the age interval 16 to 74.

Labor force participation rates are largely determined by time trends. Each equation also contains a dummy variable for a data discontinuity that followed the 1970 Census of Population. Two of the equations, those for married men and for singles, contain their respective own-group unemployment rate. In both cases the "discouraged worker" hypothesis--that high unemployment reduces the number of persons looking for work--is supported. The participation equation for married women contains the ratio of the number of children under 5 years to the number of married women. A rise in this ratio reduces labor force participation, although the effect is smaller after 1972.

Unemployment.--The numbers and percentages for total and civilian unemployment are determined residually from household-basis labor force and employment. The demographic composition of unemployment and employment are determined by two behavioral equations which explain, respectively, unemployment rates for married men and singles and related identities. Explanatory variables in the unemployment rate equations include the rate of change in total employment and in the own-group labor force, the ratio of output to potential output (to capture differences in cyclicality between groups), unemployment rates of competing groups, and the lagged dependent variable.

Insured unemployment behaves quite differently from total unemployment. The equation for insured unemployment, after adjustment for a law change in 1972, uses an error correction mechanism to distinguish long- and short-run determinants. The relative rate of change in insured unemployment is largely determined by the relative rate of change in establishment-basis employment (the major short-run determinant); the long-run determinants are overall unemployment, the ratio of average weekly unemployment insurance benefits (exogenous) to the wage rate, and the ratio of unemployed married men to total unemployment, lagged one quarter. The first of these two ratios, which is positively related to insured unemployment, reflects the "moral hazard" associated with unemployment insurance. The second ratio affects insured unemployment in both the short and long runs, and thus enters this nonlinear equation twice. The latter ratio is significant because unemployed married men are more likely to be insured than other unemployed.

7. Income and Product-Income Reconciliation

7.1 Components of national income and personal income

This section discusses the components of national and personal income, except government transfers, government interest paid, and social insurance contributions. The latter are described in Section 8. Major components of national income are compensation of employees, proprietors' income, rental income of persons, net interest, and corporate profits with inventory valuation and capital consumption adjustments. Personal income is derived from national income by subtracting corporate profits and employer and employee contributions for social insurance and adding personal interest and dividend income and government and business transfers to persons.

Compensation of employees.--The core wage component determined by the model is compensation of private domestic nonfarm employees, excluding household employees. It is obtained as the product (for these employees) of compensation per hour, employment, and average hours worked per employee. Compensation of private household employees is determined as the product of hours worked by these employees and their wage rate, which is linked to wage rates for other private sector employees. Compensation of Federal Government employees and compensation of farm employees are exogenous. Compensation of State and local employees is obtained as the product of (exogenous) real compensation and the (endogenous) implicit deflator for this compensation.

Other compensation measures are derived from the basic one. For example, the measure of hourly compensation for employees in the nonfarm business sector excluding housing is obtained by subtracting compensation for employees of nonprofit institutions and the housing sector and adding the imputed wage income of nonfarm proprietors and unpaid family workers. Estimates of employee compensation for nonprofit institutions and the imputed wage income component are functions of the broad explicit compensation measures. The (small) housing services component is exogenous.

Wages and salaries, which are used in calculating the tax base for Federal, State, local government income taxes, and social security contributions, are determined by subtracting "other labor income" and employer contributions to social insurance funds from compensation of employees. Private other labor income is determined from an exogenous ratio of such income to total private compensation. Other labor income of government employees and wage accruals minus disbursements are exogenous.

Proprietors' income.--Nonfarm proprietors' income is modeled as a share of nonfarm profit income, defined as the sum of nonfarm proprietors' income and corporate profits. This approach implicitly recognizes the residual nature of proprietors' income as a profit-type income. The share is explained as a function of changes--with distributed lags--in the logarithms of real GNP and the ratio of the deflator for personal consumption expenditures to the GNP deflator, capacity utilization, and the ratio of net business interest to nonfarm profit income. High rates of capacity utilization and rapid increases in GNP decrease the share of proprietors' income in nonfarm profit income, which is countercyclical. Increases in the ratio of the PCE deflator to the GNP deflator, which probably occur when proprietors' prices received are increasing more rapidly than costs, cause the share to rise. Finally, an increase in the ratio of net business interest to nonfarm profit income also causes the proprietors' income share to increase.

Farm proprietors' income is derived residually by subtracting from gross farm product farm capital consumption allowances, compensation of employees, net interest paid, indirect business taxes, and corporate profits and adding subsidies to farm operators, which are all exogenous.

Net interest and personal interest income.--Net interest is equal to personal interest income less interest paid by consumers and by governments plus interest paid by government to foreigners.

Personal interest income consists of monetary interest and imputed interest. The imputed interest, i.e., the sum of interest accruing to households' pension and insurance reserves and imputed interest on non-interest bearing deposits, is exogenous. A stochastic equation for monetary interest combines economic and essentially statistical determinants.

The economic component (interest income received) is specified as the sum of the relevant financial stocks (derived from Flow-of-funds data, seasonally adjusted) times the corresponding interest rate. This representation is not exact since the historically determined mix of yields on marketable securities held by households is not observed. As a proxy for this rate, an average of yields on Federal Government securities is used and the coefficients of the terms in the equation representing interest on credit market instruments and on deposits at financial institutions are not constrained to be equal.

Statistical components are required in the monetary personal interest income equation because the NIPA and Flow-of-funds data are not directly linked. The NIPA measure appears to depend not only on the sum-of-rates-times-stocks approximation for the current quarter, but also on past and future values of this approximation. The lagged effects are represented in Koyck form by inclusion of a lagged dependent variable. Future values of this variable are, of course, unknown. However, this uncertainty is taken into account in estimating the equation by assuming that the equation has a variable intercept that follows a random walk. Such an equation can be estimated by expressing it in first-difference form and adding a moving-average error term (the MA coefficient is negative under the random walk intercept hypothesis).

Interest paid by consumers, estimated in first-difference form, is a function of the change in credit extended to households, the product of this change and the interest rate on long-term Federal debt, and the change in the unemployment rate times this product. The interest rate is a proxy for the average interest rate on credit extended to households.

Net interest paid by the Federal Government is also endogenous. Interest paid by State and local governments is exogenous, but interest received by State and local social insurance funds and other State and local interest received are endogenous (see also Section 8).

Corporate profits.--In the model, corporate profits from current production is a residual that is obtained by subtracting all other income-side components from national income. Corporate profits before tax is obtained by subtracting (exogenous) inventory valuation and capital adjustments from profits from current production.

Dividends.--Corporate dividends is a function of current-quarter net corporate cash flow (profits before tax plus corporate capital consumption allowances less corporate profits taxes) and lagged dividends (averaged over the previous four quarters). Dividends are allocated between personal dividend income and State and local government dividend income by an exogenous proportion.

Rental income of persons is exogenous.

7.2 Reconciliation of GNP and national income

The reconciliation items between GNP and national income are capital consumption allowances with capital consumption adjustment (CCA), the statistical discrepancy, indirect business taxes, business transfer payments, and subsidies less current surplus of government enterprises.

Capital consumption allowances.--CCA is determined separately for residential and nonresidential fixed capital. Both equations rely on the property that, in the short run, real stocks of capital can be forecast with a high degree of precision and that, with straight-line depreciation, the ratio of constant-dollar CCA to the appropriate gross stock is essentially constant. The principal explanatory variable in each equation is the average current-dollar value of the relevant gross capital stock, obtained by averaging beginning and end-of-quarter real values and multiplying by the implicit deflator for the corresponding type of investment. The equation for nonresidential CCA also has a time trend, beginning in 1978, that accounts for the increasing proportion of computers (which are short-lived) in the capital stock.

Statistical discrepancy.--The statistical discrepancy is exogenous. Since the discrepancy has had steadily negative values since 1985, current forecasting practice is to move the discrepancy from its most recently observed value to a value near its three-year average.

Indirect business taxes (largely endogenous) are described in Section 8.

Business transfer payments are exogenous.

Subsidies less current surplus of government enterprises are described in Section 8.

8. Government Receipts and Expenditures

8.1 Federal receipts and expenditures, NIPA basis

The basic equations in the model for Federal receipts and endogenous components of Federal expenditures explain the national income and product account (NIPA) measures of these variables. A separate block of equations translates these measures into estimates of the official ("unified budget") counterparts (the only feedback from the unified budget deficits is to NIPA Federal net interest). These blocks are discussed in turn.

Federal receipts

Personal tax and nontax receipts.--Federal personal tax and nontax receipts are estimated as the sum of withheld and nonwithheld individual income taxes, which are both endogenous, and estate and gift total and nontaxes, which are exogenous. Withheld income taxes are a function of personal income tax liability and the exogenous part of this total due to taxes on capital gains. In turn, personal income tax liability under the current tax law is a loglinear function of a weighted average of various components of personal income (a proxy for adjusted gross income (AGI)), itemizable deductions at the 83.6th percentile of the distribution of itemizable deductions (which, in turn, is a loglinear function of AGI and State and local income taxes), and the rate of inflation. Nonwithheld income taxes less taxes on social security benefits are a function of non-wage income tax liability and the difference between wage liability and withholding for the prior year; both enter with distributed lags.

A satellite model provides estimates of personal income tax liability over time for given tax laws based on (exogenous) distributions of income and itemizable deductions for detailed segments of the population. The satellite model was simulated using the current tax law and different assumed values of AGI, inflation, and itemizable deductions (at the 83.6th percentile) to obtain estimated values of personal income tax liability over the forecast period. Then, these estimated values of personal income tax liability were used to estimate the personal income tax liability equation parameters for the main model.

Corporate profits tax accruals.--Federal corporate profits tax accruals, adjusted by adding investment tax credits and subtracting taxes paid by the Federal Reserve System, are estimated as a function of (1) an approximation to the tax base using NIPA variables (domestic profits before taxes less profits of the Federal Reserve System and State and local corporate profits taxes) times the top-bracket Federal corporate tax rate and (2) the Federal Reserve Board's index of capacity utilization in manufacturing.

A unitary elasticity is imposed on the base-times-rate variable; the capacity utilization variable is included to reflect asymmetry associated with losses that are most prominent in recessions and slow growth periods. The equation is expressed in first-difference form with the difference calculated over four quarters.

Indirect business taxes.--Among Federal indirect business taxes, only customs duties are endogenous in the present model. The equation for customs duties has as its dependent variable the ratio of customs duties (except petroleum import fees) to the value of merchandise imports (except petroleum). The only explanatory variable is the implicit price deflator for merchandise imports excluding petroleum; this variable has a negative coefficient, reflecting the decay in the effective duty rate as physical quantity rates (dollars per ton) are applied to imports whose nominal value are rising. Petroleum import fees have been zero in recent years. Other (exogenous) Federal indirect business taxes consist of excise taxes, Outer Continental Shelf rents and royalties, and other business taxes and nontaxes.

Social Security contributions.--Social Security contributions by and on behalf of employees (i.e., combined employer and employee contributions) are explained by the three equations that cover contributions originating in the private, State and local government, and Federal Government sectors. Explanatory variables in each equation include the Social Security employer-employee contribution rate and wage base along with relevant measures of employment and wages and salaries. Terms are included to account for the difference between employer and employee contribution rates during 1984. Social Security contributions by self-employed workers are explained (separately for each Social Security trust fund) by the product of the appropriate fund-specific contribution rate for self employed workers and proprietors' income distributed over four quarters.

Other contributions for social insurance.--Major types of employer and employee contributions are treated separately. Contributions to Federal social insurance programs other than Social Security by private sector employers is modeled as private sector wages and salaries times an average contribution rate (exogenous). Federal Government employer contributions for Civil Service retirement is the product of Federal civilian wages and salaries and the contribution rate (exogenous). All other employer contributions comprise a small exogenous residual. Employee contributions other than for Social Security consist of contributions for Civil Service retirement, contributions for supplementary medical insurance, and a second small exogenous residual. The first two of these components are determined in the unified budget sub-block; hence, the second residual contains the difference between the NIPA and the unified budget values for these components as well as employee contributions for other Federal social insurance funds.

Federal expenditures

Purchases of goods and services.--Federal purchases for compensation and purchases by the Commodity Credit Corporation are exogenous in current dollars. Other purchases are exogenous either in current or in constant dollars at the user's option by means of a switch function.

Social Security benefits.--Social Security and medicare benefits are largely determined in the sub-block for the Social Security trust funds. In that sub-block, benefits under the two Social Security programs, old-age and survivors insurance (OASI) and disability insurance (DI), and for the two medicare components, hospital insurance (HI) and supplementary medical insurance (SMI), are determined separately.

The equations determining OASI and DI benefits are similar in structure. In each case, a stochastic equation determines the average monthly benefit as a function of the average monthly benefit in the preceding quarter and, in selected quarters, a cost-of-living (COL) increase based on the change in the Consumer Price Index (CPI) over the corresponding quarter a year earlier. Through 1982, the COL increase occurred in the third quarter; there was no increase in 1983; and starting in 1984, the COL increase occurs in the first quarter. Total benefits (at annual rates) are determined as the product of the average monthly benefit, the number of beneficiaries (exogenous), and a multiplicative constant. HI benefits are given by a stochastic equation that depends on HI benefits in the preceding quarter, the relative change in the number of OASI beneficiaries (a proxy for the relative change in the number of HI beneficiaries), and the relative change in the medical component of the CPI.

An identity determines the change in the medical component of the CPI as a function of the change in the total CPI and an exogenous wedge variable. Finally, SMI benefits are determined as the product of SMI benefits in constant dollars (exogenous) and the medical component of the CPI.

Unemployment insurance benefits.--Unemployment insurance benefits consist of those under regular and extended State programs, and all other unemployment benefits. The former are endogenous, depending on (1) the product of the level of insured unemployment (see Section 6 for a discussion of the insured unemployment equation) and the average weekly benefit rate (with an elasticity close to unity), and (2) the ratio of insured to total unemployment. A positive coefficient on the second variable suggests that when overall unemployment is high, the measured average weekly benefit rate (which refers to regular benefits only) understates the effective rate; that is, it apparently accounts for rate differences with respect to regular versus extended benefits.

Other Federal transfers are exogenous.

Grants-in-aid are exogenous.

Net interest paid.--Federal net interest paid is determined as the difference between gross interest paid and interest received. Interest paid is determined as the sum of interest paid on the three major components of the publicly held Federal debt--marketable short-term (Treasury bills), marketable long-term (Treasury notes and bonds), and other (mostly savings bonds and other non-marketable securities). For each component of the debt, interest paid is represented as the product of the average amount of such debt outstanding and the relevant effective interest rate. Because several of the variables used to determine interest paid contain small but systematic measurement errors, the interest-paid relationship is formally not an identity but a stochastic equation in which the single estimated coefficient differs slightly from its theoretically expected value of 1.0. The amount outstanding and effective interest rates for marketable debt are endogenous. The amount outstanding and the effective interest rate for nonmarketable debt are exogenous.

Federal interest received is given by the average volume of Federal direct loans outstanding during the quarter and an average interest rate. Both are exogenous.

Subsidies less current surplus of government enterprises.--Federal subsidies less current surplus of government enterprises is exogenous.

8.2 Federal receipts and outlays, unified budget basis

The primary determination of Federal receipts and expenditures in the BEA model is on a national income and product account (NIPA) basis because NIPA concepts and definitions focus directly on the economic transactions through which the government and the private sectors interact. Thus, the specification of structural relationships in the government sector is facilitated by the use of NIPA measures.

However, Federal fiscal policy is formulated in terms of the unified budget (which involves both "on-budget" and "off-budget" agencies). Although the unified budget surplus (or deficit) does feed back into the main model because it helps to determine Federal net interest paid, the principal role of the unified budget sub-block is to yield additional information of interest particularly to policy makers.

The unified budget differs from NIPA receipts and expenditures in coverage, netting, and timing. Coverage differences include receipts from, and expenditures in, U.S. territories and foreign countries, which are included in the unified budget but not in the NIPA's. Netting differences arise when receipts are netted against outlays (or vice versa) in one budget but not the other. For example, voluntary supplementary medical insurance contributions are recorded as receipts in the NIPA's but are netted against medicare outlays in the unified budget.

In addition, seasonal differences between the NIPA's and the unified budget arise because NIPA Federal receipts and expenditures are seasonally adjusted while the unified budget receipts and outlays are not. Thus, as a part of the translation from NIPA to unified budget measures, NIPA seasonal factors must be obtained to convert the seasonally adjusted NIPA receipts and expenditures into their not seasonally adjusted counterparts.

Three subsets of equations comprise the unified budget sub-block. The first and most important subset--the only one described here--consists of bridge equations that translate the NIPA Federal receipt and expenditures components into their counterparts in the unified budget. The second subset explicitly accounts for differences between the NIPA's and the unified budget in a set of reconciliation items and seasonal factors. This permits construction of a reconciliation table similar to NIPA table 3.17B in the *Survey of Current Business*. This table reconciles unified budget receipts and outlays to their NIPA counterparts, not seasonally adjusted. The third and final link to the NIPA Federal receipts and expenditures, seasonally adjusted, consists of a set of three seasonal factor equations: for NIPA seasonal factors in Federal corporate profits taxes, for those in other Federal receipts, and for those in Federal expenditures, respectively.

Unified budget receipts

Typically, a unified budget receipts component is determined by a stochastic equation in which the dependent variable is a category of unified budget receipts and the main explanatory variable is a closely related NIPA counterpart. Coefficients are generally slightly greater than 1.0, reflecting the inclusion of receipts from U.S. territories in the unified budget and their exclusion from the NIPA's. Other explanatory variables differ from equation to equation, although they are generally designed to account for seasonality or timing. So far as possible, timing variables used in the reconciliation part of the sub-block are used as explanatory variables.

Unified budget receipts that are estimated as functions of corresponding NIPA receipts are: withheld personal income taxes, nonwithheld personal income taxes, employment taxes, unemployment taxes, excise taxes, estate and gift taxes, and customs duties. Federal civilian employee retirement contributions are determined as the product of civilian wages and salaries and an exogenous contribution rate. Corporate income taxes are estimated as a function of NIPA corporate profits taxes less Federal Reserve profits taxes. Miscellaneous receipts in the unified budget are constructed as the sum of Federal Reserve profits taxes, petroleum import fees (when in effect), and a small exogenous residual.

Unified budget outlays

Unified budget outlays can be classified by function or by agency. In the BEA model, outlays are classified by function. (Functions were selected for inclusion in the unified budget model if they already were represented by corresponding NIPA quantities in the BEA model.) The functions that are explained separately are: defense, health, social security and medicare, income security, agriculture, and net interest. Other unified budget functions are lumped together in "other outlays and allowances." The outlays side of the unified budget also contains undistributed offsetting receipts.

The national defense function in the unified budget is a relatively straightforward translation from NIPA-defined purchases. Military compensation and defense purchases are each estimated with simple bridge equations. Military retirement accruals, which did not appear in the NIPA's prior to the December 1985 benchmark revision, are estimated as a function of military pay.

The largest component of the health function, medicaid, is estimated as a function of its NIPA counterpart; the remainder is exogenous. Social Security and medicare outlays are each functions of their NIPA counterparts. In contrast to its treatment in the NIPA's, medicare in the unified budget is shown as net of voluntary supplementary medical insurance (SMI) contributions.

The income security function is comprised of outlays for military retirement (cash basis), Federal civilian retirement, unemployment compensation, and the residual component "other." The first three major components are explained by bridge equations with parameters near 1.0. "Other" income security outlays are explained by a specially designed variable equal to the sum of detailed components of NIPA expenditures and by Federal wages and salaries, which are a proxy for administrative costs.

The agriculture function is modeled as the sum of Commodity Credit Corporation (CCC) outlays and "other" (exogenous). The CCC component is explained as the sum of NIPA CCC inventory change, NIPA agricultural subsidies, and an exogenous residual. Net interest is explained as a function of NIPA net interest plus timing and seasonal terms.

"Other outlays and allowances" is determined as a residual. Total outlays are determined through the NIPA/unified budget reconciliation. Outlays for functions previously described and undistributed offsetting receipts are then netted out.

Undistributed offsetting receipts are receipts that are netted against total outlays. These include Federal employer contributions to employee retirement and Outer Continental Shelf (OCS) rents and royalties. Federal employee retirement is the sum of military retirement accruals (discussed above) and Federal civilian employee contributions, which are explained as the product of civilian wages and salaries and a contribution rate.

OCS rents and royalties are the sum of two exogenous components--royalty payments on oil produced on the OCS, which are part of business nontaxes in the NIPA's, and the sale of drilling rights on OCS land, which are part of net purchases (sales) of land, a reconciliation item.

8.3 State and local government receipts and expenditures

State and local receipts

State and local government receipts are estimated in five categories: personal tax and nontax receipts, corporate tax accruals, indirect business tax and nontax accruals, contributions for social insurance, and Federal grants-in-aid. Only grants-in-aid are exogenous.

Personal tax receipts.--Personal income tax receipts are estimated as a fraction of a proxy for adjusted gross income (AGI). This fraction, an estimate of the average personal tax rate, is a function of a proxy for revenue requirements (State and local expenditures less social insurance expenditures and Federal grants-in-aid) and a proxy for total revenue expectations (total State and local receipts excluding social insurance contributions and grants-in-aid). The latter proxy is estimated as a function of the proxy for revenue requirements, two cyclical indicators (the index of capacity utilization and the civilian unemployment rate), current-dollar structures purchases as a fraction of total expenditures (a proxy for borrowing), and the lagged State and local surplus excluding social insurance funds (a term that tends to increase or decrease revenues as they are needed to balance the budget). Other State and local personal tax and nontax receipts are estimated as an exogenous fraction of current dollar consumption of services excluding housing, electricity and gas, other household operations, and transportation.

State and local corporate profits tax accruals are estimated as a ratio to domestic corporate profits less profits of the Federal Reserve System that increases with the proxy for revenue requirements described above, as well as with a time trend.

Indirect business taxes are estimated in four categories: gasoline taxes, other sales taxes, taxes on residential real estate, and other indirect business taxes and nontaxes. Each component is estimated with the dependent variable as a ratio to an appropriate tax base, such as personal consumption expenditures on gasoline or the current-dollar value of residential real estate. The proxies for revenue requirements and for revenue expectations relative to the relevant tax base are used to determine the variations in these tax rates.

Contributions for social insurance by employers and employees are estimated as products of exogenous contribution rates and appropriate proxies for taxable wages and salaries.

State and local expenditures

State and local expenditures are estimated in six categories: purchases, transfers, net interest paid, dividends received, subsidies less current surplus, and wage accruals less disbursements. Dividends received are an offset to expenditures (they enter with a negative sign). Of these major categories and their components, interest received, social insurance fund transfers, and wage accruals less disbursements are exogenous.

Purchases of goods and services are estimated in three constant-dollar components: compensation of employees, structures, and other. Their current-dollar counterparts are formed by multiplying them by corresponding price deflators, which are also endogenous (see Section 5). Compensation of employees expressed per capita (where the divisor is total civilian and military population) is a function of real disposable income expressed per capita (where the divisor is the population aged 16 years and older), the fraction of the total population aged 6 through 15, and the State and local budget surplus excluding the social insurance funds (not surprisingly, surpluses lead to more hiring). An equation for noncompensation purchases, also on a per capita basis, is driven by per capita constant-dollar personal income and the price of these purchases relative to the personal consumption deflator. Noncompensation purchases are then separated into its components, structures and other, by means of an equation for the non-structures portion. It is a function of the population aged 6 through 15 divided by the population 16 and over, and the stock of State and local government structures per capita.

Transfers to persons, except state and local insurance fund payments, which are exogenous, are estimated on a constant-dollar per capita basis. They increase with constant-dollar per capita income and with the civilian unemployment rate.

Net interest paid equals interest paid, which is exogenous, less interest received. Interest received is comprised of interest received by social insurance funds and other accounts. Interest received by the social insurance funds is estimated by an equation that explains the average return of state and local social insurance funds as a function of Moody's average long-term bond yield. The average return, the equation's dependent variable, is defined as the sum of interest and dividends received by social insurance funds divided by the stock of such funds. Interest received by the other funds is estimated as the net return on the stock of these funds, which varies with the commercial paper rate and the Moody's average long-term bond rate. Both stocks of funds are estimated as the sum of last period's stock and this period's surplus, divided by 4 to put the surplus at a quarterly rate.

Dividends received are an exogenous fraction of total dividends.

Subsidies less current surplus of government enterprises is a function of Federal grants-in-aid and State and local expenditures other than social insurance funds. It is estimated with a Koyck lag.

9. Finance

The financial sector of the model primarily determines interest rates and monetary aggregates. The equations that determine these variables are described in turn.

9.1 Interest rates

All the interest rates that are directly determined in the financial sector are effective yields on the instruments, the effective yield being defined as the before-tax interest return per invested dollar per year, assuming reinvestment and compounding at the same rate as any cash interest received.

Short-term rates.--The principal monetary policy variable in the model is the effective 3-month Treasury bill rate (RTBEFF). It is estimated using a Federal Reserve reaction function, i.e., an equation that simulates the reactions of the Federal Reserve System to the economic environment. Specifically, the 3-month Treasury bill rate is made a function of expected inflation, the level and the first-differences in the civilian unemployment rate less the cyclically adjusted unemployment rate, and, since 1982-IV, the rate of increase of the M2 money stock. Expected inflation is proxied by a weighted sum of contemporaneous and lagged rates of increase in a price deflator for a variant of private domestic GNP. The bill rate varies positively with expected inflation and the rate of change in M2 and negatively with the two unemployment variables. Historically, certain parameter shifts are justified for this equation. For example, the response to inflation jumps in 1979-IV, while the response to unemployment diminishes.

Most other short-term rates--the Federal funds rate, the 4-6 month commercial paper rate,the average rate on money market funds, and the auto loan rate--are directly or indirectly functions of RTBEFF. For example, the auto loan rate is directly related to the commercial paper rate.

Long-term rates.--The interest rate on Moody's seasoned AAA corporate bonds varies with the real short-term interest rate (the commercial paper rate less the same inflation expectations proxy as used in the bill rate equation), inflation expectations, and longer-term expectations of these two variables defined as exponentially smoothed moving averages. A second long-term rate, Moody's average long-term corporate bond yield, varies directly with the AAA rate and inversely with the capacity utilization rate. The effective mortgage rate on newly built homes varies with the commercial paper rate and the average long-term bond yield.

9.2 Monetary aggregates

The principal equation determining the monetary aggregates is the demand function for M2, i.e., M1 (currency plus demand and other checkable deposits) plus time and savings deposits, money market funds, and overnight repurchase agreements and Eurodollar deposits. The dependent variable is specified in velocity form, i.e., the ratio of M2 to "domestic product", where the latter is defined as current-dollar GNP less rest-of-the-world product, Federal Government product (employee compensation), and a large portion of Federal noncompensation purchases. The transactions variable (i.e., the denominator) is defined so as to correspond to holders of M2. M2 velocity varies inversely with the Treasury bill rate and the rate of change in domestic product and directly with the average interest rate on the components of M2.

M2 feeds back into the model principally through the reaction Federal Reserve function. Jointly, the (M2) money demand function and the reaction function--effectively, the central banks money "supply" function--yield a rather flat "LM" curve, i.e., the loci of income/interest-rate equilibria of the Keynes-Hicks paradigm.

M2 is split into major components, using a Brainard-Tobin system of equations. Specifically, this system yields estimates of M1, small time and savings deposits, money market funds, Eurodollar deposits at Caribbean banks and overnight repurchase agreements, and a residual category. The system contains several short-term interest rates. Smaller aggregates are for the most part broken out with exogenous fractions, but a behavioral equation breaks out money market funds. There is a separate equation for currency.

The financial sector also contains equations for nonborrowed and required Federal Reserve System member bank reserves. However, these aggregates, which are critical in some monetary models in which nonborrowed reserves is treated as the principal monetary policy instrument, play a minor role in the BEA model; their only role is to help determine Federal Reserve holdings of Federal marketable debt and thus the Federal Reserve System component of corporate profits.

III. RESPONSE CHARACTERISTICS OF THE MODEL

One of the two major uses of the BEA quarterly model is the analysis of the impact on the economy of alternative economic policies and other contingencies. Put another way, the model is useful in answering a variety of "What if...?" questions. The other major application is economic forecasting. This chapter focuses on the properties of the model that relate particularly to the first type of application.

In practice, policy changes do not occur in a neatly stylized form. Real-world tax cuts do not typically occur once and for all on some particular date; rather, they tend to be phased in over several periods. Defense expenditures do not rise or fall all at once by fixed amounts and may well be offset by compensating adjustments in other Federal Government expenditures and with different timing. The Federal Reserve Board may or may not alter its policy in response, depending on a complex of domestic and international economic circumstances. Oil prices may fall sharply one quarter only to rise a half year later.

When alternative forecast scenarios are processed, such complexities must be built into the assumptions. However, when the objective is, as in this presentation, to reveal how the model functions (that is, how it responds to given economic stimuli and what the key underlying qualitative and quantitative characteristics of the model are that make it respond as it does), then the system must be shocked in a systematic and somewhat artificial manner. Such an analysis can be carried out by standard multiplier simulations.

For this presentation, the 1990 version of the BEA model described in this report was subjected to five stylized shocks, each evaluated over a 5-year period: (1) an increase in real defense purchases equal to 1 percent of the baseline solution levels of real GNP, (2) the same shock with an accommodating monetary policy, i.e., one in which the Treasury bill rate is held at baseline levels, (3) a decrease (from baseline levels) of 1 percentage point in the Treasury bill rate, (4) a decrease of 20 percent in the average world crude oil price, and (5) a 10-percent decrease in the foreign exchange rate of the U.S. dollar.

The baseline solution for these tests essentially used historical predetermined variables for the period 1985-I to 1989-IV as inputs. However, the baseline solution deviates from a perfect "tracking" solution in one important respect: the output levels were modified, by manipulating real State and local government goods purchases, to yield a civilian unemployment rate of about 6 percent. The unemployment rate is a critical variable because it determines the mix of quantity and price responses to a given demand stimulus. A natural extension of our experiments that would establish the degree of this sensitivity is to repeat them using alternative baseline solutions with different (controlled) unemployment rates.

Detailed description of the assumed shocks

(1) Increase in defense purchases with non-accommodating monetary policy.--As noted in Section 8 of Part II, Federal noncompensation purchases may be made exogenous in constant or current dollars. For this simulation, the increments to defense goods purchases, relative to baseline levels, were made in constant dollars. Thus, there is no negative feedback of higher prices resulting from this fiscal stimulus to real defense purchases. However, real nondefense purchases were set exogenously in current dollars so that real nondefense purchases were reduced by higher nondefense goods prices.

Monetary policy was controlled by the Federal Reserve reaction function described in Section 9 of part II. Under this regime (the model's usual operating mode) interest rates rise under the impact of the fiscal stimulus through the combined effects of higher prices, increased money demand, and lower unemployment.

(2) Increase in defense purchases with accommodating monetary policy.--The increase in defense purchases was handled the same way as in (1), except that the Treasury bill rate was held at baseline levels by turning off the reaction function.

(3) Decrease in effective Treasury bill rate.--The bill rate was made exogenous, as in (2), and set 1 percentage point below baseline levels, thus defining a monetary stimulus. Defense purchases were set exogenously in current dollars (the normal operating mode); consequently, negative feedbacks due to higher prices occur with respect to defense purchases as well as nondefense purchases.

Note.--The second and third simulations are the only ones in which the estimated Federal Reserve reaction function was suppressed.

(4) Decrease in world crude oil price.--The price of imported oil was decreased 20 percent below corresponding baseline levels. Current-dollar oil imports (exogenous in the BEA model) were set 16 percent below baseline levels, implying a price elasticity of demand for imported oil of -0.2. The Producer Price Index for refined petroleum products was set 17 percent below baseline levels, less than the 20 percent drop in world crude oil prices because of assumed unchanged refining costs. The Producer Price Index for electric power was reduced 1 percent to reflect the pass-through of lower generating costs attributable to lower oil prices.

(5) Decrease in exchange rate.--The (exogenous) 9-country trade-weighted index of the value of the U.S. dollar was decreased 10 percent below corresponding baseline levels.

Results

Charts 1 through 3 show, in compact form, the key results from all five multiplier simulations. Chart 1 shows the percent differences from baseline levels in real GNP. Chart 2 shows the corresponding percent differences in the implicit price deflator for GNP and Chart 3 depicts the direction and relative contributions of the major product components of real GNP in the quarter in which the real GNP multiplier peaks for that simulation. The latter chart in itself provides a good deal of analytical information about the model's operating mechanisms.

(1) Increase in defense purchases with non-accommodating monetary policy.--Because the normalized input of incremental real defense purchases is 1 percent of baseline real GNP, the values shown in Chart 1 for each of the two variants of the fiscal shock can be directly read as multipliers, i.e., as ratios of the output response to the input. In the non-accommodating monetary policy case (NAMP), the real GNP multiplier is 1.1 in 1985-I (the "impact" quarter), rises to a peak of 1.9 in 1986-II, then recedes to 0.1 by 1989-IV (the end of the simulation period). The basic multiplier-accelerator mechanism that is inherent in the consumption and nonresidential fixed and inventory investment equations is what drives the GNP response to its peak, as can be seen from the positive contributions of these components in Chart 3 (leftmost stacked bar diagram). The response in real net exports, which mainly reflects an income effect that raises real imports, is a "leakage" factor holding down the GNP multiplier.

The subsequent reversal of the real GNP multiplier is caused by the combined effects of higher interest rates, higher prices, and the accelerator mechanism inherent in the fixed investment, inventory investment, consumer auto purchases, and to some degree in nonauto consumer durable goods purchases.

The Treasury bill rate is 77 basis points above baseline at the GNP multiplier peak in the NAMP simulation. This differential interest rate peaks one quarter later, then recedes somewhat in response to the weakening demand multiplier. The differential in the effective corporate bond yield, which is representative of the interest rates that particularly affect investment in producers' durable equipment and residential construction, however, continues to rise throughout the simulation, reaching 61 basis points by 1989-IV. The small negative impact of higher interest rates on residential construction outlays is seen in Chart 3.

The inflationary response to the demand stimulus occurs with a lag. As can be seen in Chart 2, the price level actually falls a bit below baseline levels for the first few quarters; this results from a productivity spurt associated with the demand shock that initially dominates the demand pressure itself. This strongly reverses as the demand pressure continues; by 1989-IV, the GNP deflator (PGNP) is nearly 2.5 percent above baseline. The demand pressure works both through the average wage in the nonfarm business sector, which is already 0.7 percent above baseline in the peak GNP multiplier quarter, and, more directly, through the demand pressure variables in the domestic driver price equation. The wage rate response, in turn, reflects the lower unemployment rates that accompany higher real output; the civilian unemployment rate is 1 percentage point below its baseline level in 1986-II.

The importance of the inflationary response in reversing the real GNP response is seen in the fact that the ratio of the percent difference in constant-dollar GNP to that in current-dollar GNP (i.e., the relative share of the "real" component of the nominal GNP multiplier) is 0.90 in the peak quarter and only 0.06 in the final quarter. Several mechanisms cause higher prices to "crowd out" the real responses: (1) Expectations and "real balance" effects in the consumer sector, (2) an unfavorable shift in the terms of international trade, (3) the sensitivity of personal income taxes to inflation, and (4) the fixing of Federal nondefense purchases in current dollars.

(2) Increase in defense purchases with accommodating monetary policy.--The effects of shifting the underlying monetary policy assumption from (1) a non-accommodating policy that obeys the reaction function to (2) a fully accommodating one in which interest rates are held to baseline levels (i.e., to levels that would have obtained if the Federal Reserve deliberately conducted open market operations so as to yield the rates that would have materialized in the absence of the fiscal shock) are seen in the three charts: The real GNP multiplier peaks at 2.2 percent with accommodating policy, compared to 1.9 percent in non-accommodating case, and 2 quarters later. A larger difference is maintained after the peak in the accommodating case, although it substantially narrows towards the end of the simulation. This narrowing reflects the stronger inflationary response in the accommodating than in the non-accommodating case. By 1989-IV, the difference in the GNP deflator is 3.1 percent in the accommodating case, compared to 2.5 percent in the non-accommodating case.

As shown in Chart 3, the consumption, fixed business investment, and inventory investment components of the real GNP multiplier in the peak quarter are each larger in the accommodating case than the corresponding components in the non-accommodating case. Residential investment, instead of showing a negative response, displays a small positive response; by assumption, there is, of course, no offsetting interest-rate effect.

(3) Decrease in Treasury bill rate.--A sustained 1-percentage point reduction in the 90-day Treasury bill rate induces a rise in real GNP, mainly via the interest-sensitive residential and producers' durable equipment components. The GNP response essentially plateaus at around 0.85 percent above corresponding baseline levels from 1986-IV through 1987-IV (it peaks in 1987-II at 0.87 percent) and then gradually recedes to 0.4 percent. As with the fiscal stimulus, the initial expenditure stimulus--in this instance, fixed investment and consumer auto purchases instead of Government purchases--result in induced income effects on consumption and trade and induced inventory investment via larger sales. Induced consumption is, however, sharply limited by the negative effect of lower interest rates on personal interest income; in the peak quarter, personal interest income is $21 billion below its baseline level, thus offsetting about three-fifths of the sources of increase in personal

income. The effect on consumption is, on the other hand, mitigated somewhat by the fact that the model imposes a lower marginal propensity to consume with respect to interest income than to other disposable personal income.

As a result of smaller output increases and unemployment decreases than in the fiscal multiplier simulations, prices also rise much less; in 1989-IV, the increase in the GNP deflator over its baseline level is just 1 percent.

(4) Decrease in world oil price.--The assumed sustained 20 percent decrease in the world crude oil price produces by 1986-I a maximum decrease in the GNP deflator of 0.64 percent. Because the fall in the price of imported oil tends to reduce the negative impact on the GNP deflator, its maximum reduction is not as great as that in the PCE deflator, which is 0.95 percent in 1985-IV. The resulting lower oil product prices, and, to a slight degree, in electric power prices, directly stimulates final demand for these energy products. Because of the pass-through of lower oil product prices from all types of intermediate goods and services to final product (as embodied in the domestic driver price equation), other real demand is stimulated as well. This stimulus has a positive impact on prices in general, thus tending to offset the initial negative effect of lower oil costs. Indeed, over the 5-year simulation, this initial effect is virtually neutralized, as can be seen in Chart 2.

The positive output impact peaks quite early (1986-I) at 0.76 percent above its baseline level, coincidentally with the maximal decrease in the GNP deflator. As in the previous simulations, final demand responds sensitively to the positive reversal of prices.

(5) Decrease in dollar exchange rate.--The assumed sustained 10 percent decrease in the value of the dollar directly affects the dollar volumes of merchandise imports and exports and the implicit price deflators for merchandise and services imports and merchandise exports (the latter, through assumed competitive effects). It raises the value and volume of exports by reducing the relative price of U.S. exports to foreigners. It reduces the value and volume of imports because foreign goods and services have become relatively expensive for Americans. The imports deflator adjusts, with a distributed lag, as the dollar price of imports rises. The effect on real GNP is quite strong, with the percentage increase over baseline level peaking at 1.4 in 1987-I. Chart 3 clearly reveals the underlying mechanism: The decrease in the value of the dollar stimulates the economy as a whole through the marked increase in real net exports--53 percent of the increase in real GNP in the peak quarter.

Although the strength of the real GNP response is comparable to those of the fiscal stimulus after the latter passed their peaks, the response of the GNP deflator is--as in the oil price reduction simulation, but even more so--mitigated by the increase in imports prices. In 1989-IV, the GNP deflator is 1.5 percent above its baseline level, compared to 2.5 percent and 3.1 percent, respectively, in the two fiscal shock simulations.

Chart 1—Real GNP Multipliers

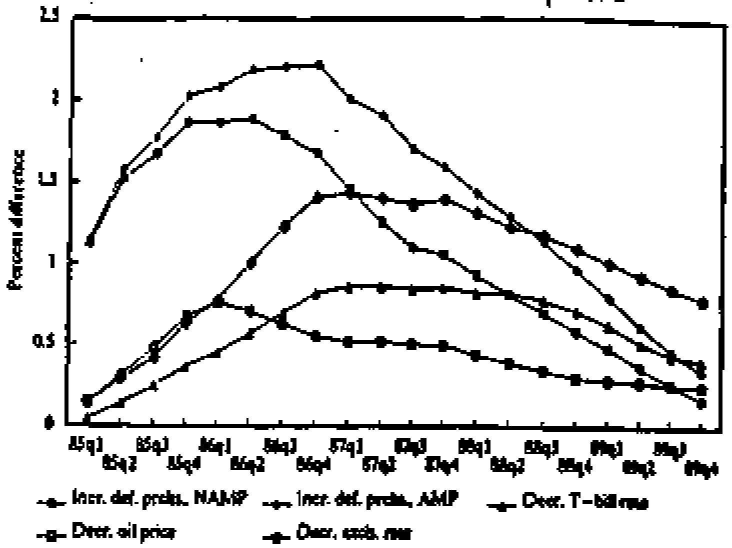


Chart 2—Price Multipliers: PGNP

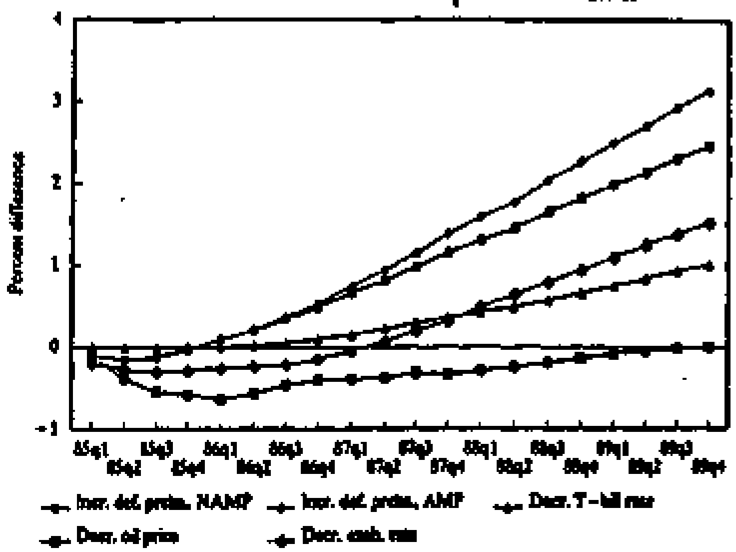
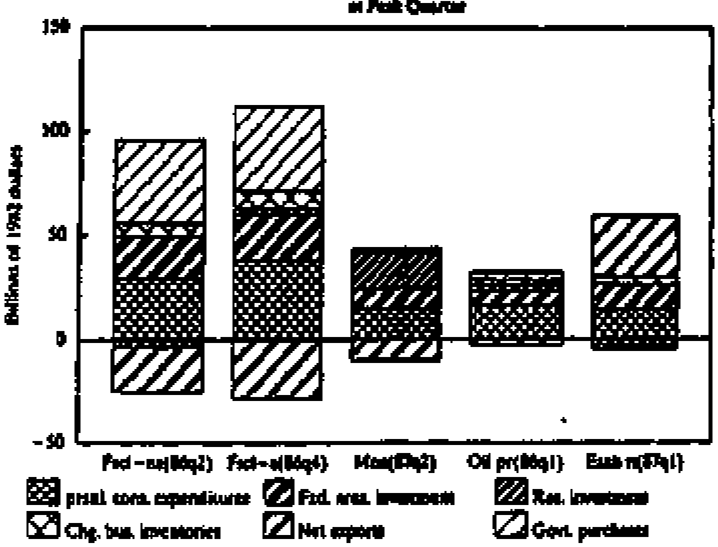


Chart 3—Composition of GNP Multipliers

at Peak Quarter



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